Architecture Engineering:
An Essential Role for Net-Centric Enablement within NATO

Frederick I. Moxley, Ph.D. and **Clinton P. Blackman, Ph.D.**

Defense Information Systems Agency
U.S. Department of Defense
P.O. Box 4502, Arlington, VA 22204

Defence Science & Technology Laboratory
UK Ministry of Defence
Portsdown, UK

moxleyf@ncr.disa.mmil

cpblackman@mail.dstl.gov.uk

ABSTRACT

The North Atlantic Treaty Organization (NATO) is presently undergoing an information age transformation, one that embraces a relatively new concept known as NATO Network Enabled Capability (NNEC). Based primarily on the Network Centric Warfare (NCW) paradigm, the intent of the NNEC is to leverage and improve upon the quantity and quality of information made available to the warfighter-peacekeeper anytime, anywhere, i.e., upon demand. This paper examines the benefits of net-centric enablement and highlights a work in progress by the NATO Open Systems Working Group (NOSWG), of the NATO C3 Board Information Systems Sub-Committee that is currently underway.

INTRODUCTION

Most international operations in which the North Atlantic Treaty Organization (NATO) is involved today tend to be quite diverse in size and scope. No longer just limited to members of the alliance, international operations often require participation from NATO and Non-NATO nations alike. Once considered to be a realm restricted to the military alone, Non-Governmental Organizations (NGO)[1] now are viewed as viable contributing players. Due to the sheer nature and complexity involved with international operations, the need to disseminate accurate and timely information is essential. To do so within such environments however, requires that superior information sharing capabilities exist at a scale far greater than ever before. Furthermore, the underlying architecture(s) must be flexible enough to address the requirements necessary to integrate new and emerging technologies into the current baseline.

Recognizing that it must focus on an approach that would best suit the technological and organizational needs of its member states, as well as promote interoperability amongst its coalition partners, NATO leaders met at the Prague Summit during October of 2002 and agreed to streamline its overall command structure. Based on the principles of this streamlining effort, the NATO Consultation, Command and Control Board (NC3B) agreed shortly thereafter to develop a concept that would build upon the tenets of such national efforts as the U.S. Network-Centric Warfare (NCW) [1] and UK Network Enabled Capability (NEC) [2] programs. At the direction of the NC3 Representatives, an Ad Hoc Working Group (AHWG)[2] was formed to develop a feasibility study for this purpose. The resulting effort became known as the NATO Network Enabled Capability (NNEC) concept.

---

[1] NGO – a non-profit citizens group that performs a variety of services and humanitarian functions to include helping to monitor and implement international agreements.

[2] ACC/322-WP(2003)029 (INV). This AHWG has since become the Feasibility Study Steering Group.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 DEC 2005	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Architecture Engineering: An Essential Role for Net-Centric Enablement within NATO	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Defense Information Systems Agency U.S. Department of Defense P.O. Box 4502, Arlington, VA 22204	

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM202135, RTO-MP-IST-042. Coalition C4ISR Architectures and Information Exchange Capabilities (Les architectures C4ISR et les capacites d'echange d'information en coalition)., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**33**	

NNEC ATTRIBUTES

Central to understanding Net-Centric enablement is the need to transform NATO and the way it thinks, i.e., to become Net-Centric. The NNEC concept is one of the key concepts at the heart of NATO transformation [3]. It is about the people, organizations and countries being empowered to work together in new and more dynamic, flexible, and effective ways, than it is about technology. Yet it is technology that provides information with the scope, speed and richness necessary to enable this transformation to take place. By its very nature NNEC and Transformation is more about a journey than it is about a destination, a journey where organizational and technological innovation and change must work hand-in-hand to achieve transformation.[3]

The overall intent and primary focus of the NNEC concept is to capitalize on those innovative technologies and capabilities that can sustain information superiority across NATO, i.e., to provide the warfighter-peacekeeper with the means necessary to accomplish mission goals and objectives in a highly effective manner. It entails a new way of thinking, and doing business in innovative ways. Once fully implemented, it will have global implications that will extend across the entire spectrum of NATO operations, worldwide.

FOCUS ON TRANSFORMATION

In order to implement the NNEC concept across NATO, certain priorities must be in place and acted on accordingly. Chief among these is the strategic focus placed on transformation. A primary proponent in developing transformation approaches, the Headquarters Supreme Allied Command Transformation (ACT) has been collaborating with the working groups and sub-committees of the NC3B, the Feasibility Study Steering Group, as well as other operational and research organizations throughout NATO to make NNEC a reality. Although a monumental task, collectively they are defining the processes necessary to transform today's platform-centric force into one that is net-centric based.

Network Centric Warfare: a warfighting concept that enables a network centric force to significantly increase combat power by achieving:
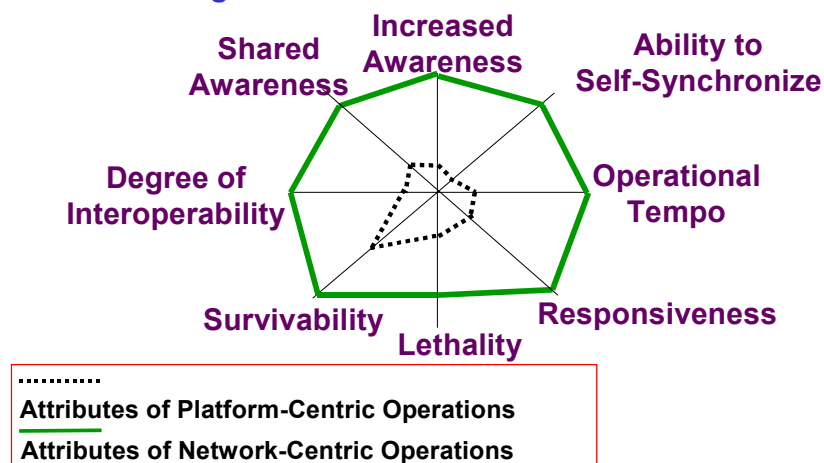
Increased Awareness
Shared Awareness
Ability to Self-Synchronize
Degree of Interoperability
Operational Tempo
Survivability
Lethality
Responsiveness

.... Attributes of Platform-Centric Operations
Attributes of Network-Centric Operations

Figure 1: Net-Centric enablement enhances information sharing capabilities.

---

[3] Paraphrased from the introductory section of the Feasibility Study Statement of Work.

NNEC IS A FORCE MULTIPLIER

It has been said on numerous occasions that the most practical way of proving a concept is by putting it to the test. The manner in which the NNEC will be put to the test is through the NATO Response Force (NRF). The primary purpose of the NRF is to provide a deployable force capable of addressing a full range of alliance missions to include the global fight against terrorism. The NRF has at the heart of its mission to be a technologically advanced, flexible, deployable, interoperable and sustainable force, whether on land, at sea, or in the air. When applied within the NRF, it is anticipated that NNEC will act as a force multiplier by providing many of these capabilities [4]. Noting the need to embrace the NNEC concept within the NRF as soon as feasibly possible, General Kujat, the NATO CMC stated that

"The NRF must be rapidly deployable, Network-Centric, able to quickly achieve effects, with capable command and control, intelligence, surveillance and reconnaissance systems that operate collaboratively while providing a common operation picture."[4]
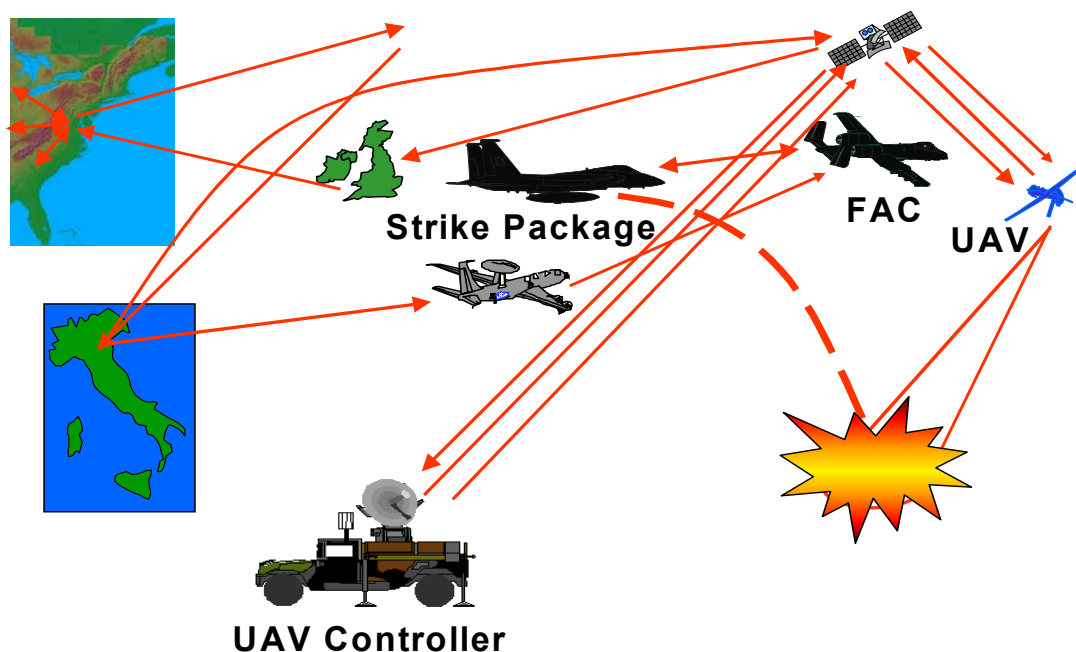
Figure 2: Global reach of Net-Centric enabled Operations.

Addressing the NRF challenges as stipulated above requires that the NNEC concept move forward at an accelerated pace and yet, be built upon a solid technical foundation. The NATO Consultation, Command and Control Technical Architecture (NC3TA) provides such a base on which to build.

---

[4] General H. Kujat, NATO CMC, Iraq Conflict Initial Observations Seminar, July 2003.

NC3TA AS NNEC KEY ENABLER

The NC3TA directly promotes the tenets of the NNEC. Whether facilitating information sharing capabilities among NATO Common Funded (NCF) systems, or between NATO and national systems, or NGOs, the NC3TA is a key enabler. It is a work that is the result of bringing together a large body of corporate knowledge gained from national and international research and development activities coupled with the direct application of the knowledge and experience of national technical experts. By its very nature, the NC3TA is an NNEC enabler of information sharing that forms the structural basis in which systems are designed and developed.[5] For that reason, it must support current architecture paradigms, as well as evolve rapidly enough to keep abreast of new and emerging technologies. By focusing on the boundaries between systems, the NC3TA supports the architectural diversity and independence of systems.

In maximizing the use of open, well-supported standards for services, protocols and data formats, it promotes the implementation of loosely coupled yet highly cohesive interfaces. It is an approach that provides the ability to adapt and evolve to meet future information sharing requirements. Furthermore, the NC3TA actively supports heterogeneity amongst the products used to implement systems, a feature that is essential where many and various NCF and national systems are required to share information and capabilities.

Although the NC3TA has provided significant advances with regard to information sharing in recent architecture paradigms (e.g., messaging and component architectural approaches), it is believed that this contribution will be even more successful with an enterprise services architecture approach envisaged for net-centric enabled environments. Governance of the NC3TA is the responsibility of the NOSWG. To manage and maintain the NC3TA's relevance, the NOSWG has adopted a proactive refresh cycle so that updated versions are released on an annual basis. It is a work in progress that is readily available on the Internet. This essentially helps to ensure that it reaches the widest possible audience.

Implementation of the NC3TA is mandatory for all NCF Systems and as a result, forms the basis for major NATO systems such as the Bi-SC AIS [5]. It is expected that in the near future nations participating in NATO operations will formally agree to use the mandatory standards included in the NC3TA in order to interoperate with NATO systems while engaged in NATO operations. Currently, the NC3TA is already used as the basis for information and capabilities sharing direction and guidance by many of NATO's member nations, as well as PfP and other coalition partners.[6]

ARCHITECTURAL VISION

The NOSWG is increasingly aware of the need to support new and developing architectures. NATO, together with a number of member nations are actively engaged in fundamental revisions of their information infrastructure architectures driven by the need for greater flexibility of deployment. Service-based and net-centric enabled architectures are beginning to replace the current system-of-systems architectural paradigms currently in use. Greater simplicity is required within the architectures to counterbalance the increasing complexity of future information infrastructures and support the need for greater scalability, flexibility, and cost effectiveness.

Realizing NNEC can only be achieved by evolving the NC3TA to support a system-of-services architecture paradigm, through a transition from component-based architectures to web services and other web-enabled technologies, the NOSWG must begin to consider evolutionary architectures as they continue to emerge. Such a transition is essential if the level of information sharing capabilities between coalition partners is to move from the simple sharing of data to include workflow and process/activity information

---

[5] Major General Frans Picavet, Director NATO C3, NATO HQ, Brussels, Belgium

[6] The URL for the NC3TA is http://194.7.80.153

consolidation. Identifying and adopting open standards that provide the ability to represent standard syntactic and semantic declarations through the use of controlled vocabularies will be a considerable though necessary task. Issues such as syntactic conflict, semantic conflict, semantic accuracy, and data consolidation will need to be addressed, as will ontologies, though these are probably further in the future.

RESTRUCTURING FOR THE FUTURE

Fully embracing the tenants of the NNEC concept, the NOSWG is in the process of restructuring the NC3TA. To better reflect its new direction, a name change for the NC3TA has been proposed by the NOSWG to indicate the role it will play during the architectural design and development of systems across NATO.[7]

When assessing the potential impacts of the NNEC concept on the last version of the NC3TA, it was also determined that it should be both modernized and streamlined to exemplify the net-centric influence that has taken shape during this restructuring effort. As a result, the following three categories of NNEC value added products have been identified as essential:

1)   a NATO Network-Enabled Capability Reference Model (NNEC-RM);
2)   Net-Centric Standards Profiles (NCSP) with specific domain community of interest based profiles (e.g., NRF), and;
3)   NATO Net-Centric Enterprise Services (NNCES)

Although not entirely inclusive, these product changes have been identified by the NOSWG as deliverables within its Programme of Work (POW). It is expected that a draft outline for each of these products will be developed by December of 2004.

ROLE OF RESEARCH ORGANIZATIONS

With respect to the future of the NNEC, several topics still need to be addressed to include the selections of suitable open standards, as well as the products and services that must be identified. Moreover, the insertion of emerging technologies associated with net-centric enablement, information management, semantics and ontologies will need to be examined on a continual basis. The NOSWG draws upon the expertise of many national experts and organizations in compiling its vast body of corporate knowledge. Achieving its new vision will likewise require input from the research communities of the NATO nations, such as those represented at this Symposium.

CONCLUSION

The NC3TA plays an important part in support of the NNEC concept, and ultimately NRF operations. It offers broad and vital support for the design and development of systems seeking to attain information superiority. It also has much to offer the coalition CIS (C4ISR) architectures that are the particular focus of this symposium and their information exchange capabilities. However, in order to realize its vision, the NOSWG must continually rely on vital research activities such as yours in order to shape its future direction and maintain the benefit that it delivers to the organization as a whole.

---

[7] The name "NATO Foundation for Architecture Engineering" has been proposed to the NC3B ISSC

Figure 3: Emblem for NNEC [8] indicating a new direction and focus of effort for NATO

REFERENCES

[1] Vice Admiral Arthur K. Cebrowski and John J. Gartska. "*Network Centric Warfare: Its Origin and Future*", Proceedings of the Naval Institute 124:1 (January, 1998), pp.28-35.

[2] NEC Outline Concept Part 1 -Background and Programme of Work. Dstl/IMD/SOS/500/2, Issue 2.0 (2 May 2003).

[3] Tom Buckman. *NNEC Feasibility Study, Context, Scope, Objectives*. Proceedings of the 2004 NATO Network Enabled Capability Conference, Norfolk, VA.

[4] Major General Ruud van Dam. Proceedings of the 2004 NATO Network Enabled Capability Conference, Norfolk, VA.

[5] Frederick I. Moxley, Lucien Simon and Elbert J. Wells. *A Foundation for Coalition Interoperability Using NATO's C3 Technical Architecture*. Crosstalk: The Journal for Defense Software Engineering (August, 2001), pp. 4-8.

FIGURES

[1&2] Adapted from David S. Alberts, John J. Garrtska, Richard E. Hayes and David A. Signori. *Understanding Information Age Warfare*. DoD CCRP, Washington, D.C. (August, 2001).

DISCLAIMER

This paper does not necessarily reflect the official views of NATO, the US DoD or UK MoD, or their respective governments. The ideas are those of the authors and are intended to provoke thought and discussion regarding the subject matter.

---

[8] 2004 NATO Network Enable Capability Conference, Norfolk, VA

ABOUT THE AUTHORS

Dr. Frederick I. Moxley is Chairman of the NATO Open Systems Working Group of the NATO C3 Board's Information Systems Sub-Committee. His national duties include serving as Chief, Net-Centric Information Engineering within the Defense Information Systems Agency (DISA), United States Department of Defense (DOD). Over the course of his career, he has designed, developed, implemented and managed a variety of software systems for DOD, as well as other agencies throughout the federal government. His primary research interests include distributed system design methodologies, architectural design patterns, artificial intelligence and software engineering. Dr. Moxley holds advanced degrees in Telecommunications and Information Systems and Sciences.

Dr Clinton P Blackman was chairman of the NATO Open Systems Working Group between 2001 and 2003, during the time that he acted as Deputy Director for Interoperability within the Equipment Capability area of MoD. Prior to his defence career, Dr Blackman held research appointments at Sussex and Edinburgh universities, where he specialised in the structure and dynamics of spiral galaxies. Dr Blackman's varied career since then has included work in Ballistics, Robotics and Research Management. He is currently working in ISTAR within the Defence Science and Technology Laboratory at Portsdown, UK.

Architecture Engineering:
An Essential Role for Net-Centric Enablement
within NATO

Dr. Frederick I. Moxley
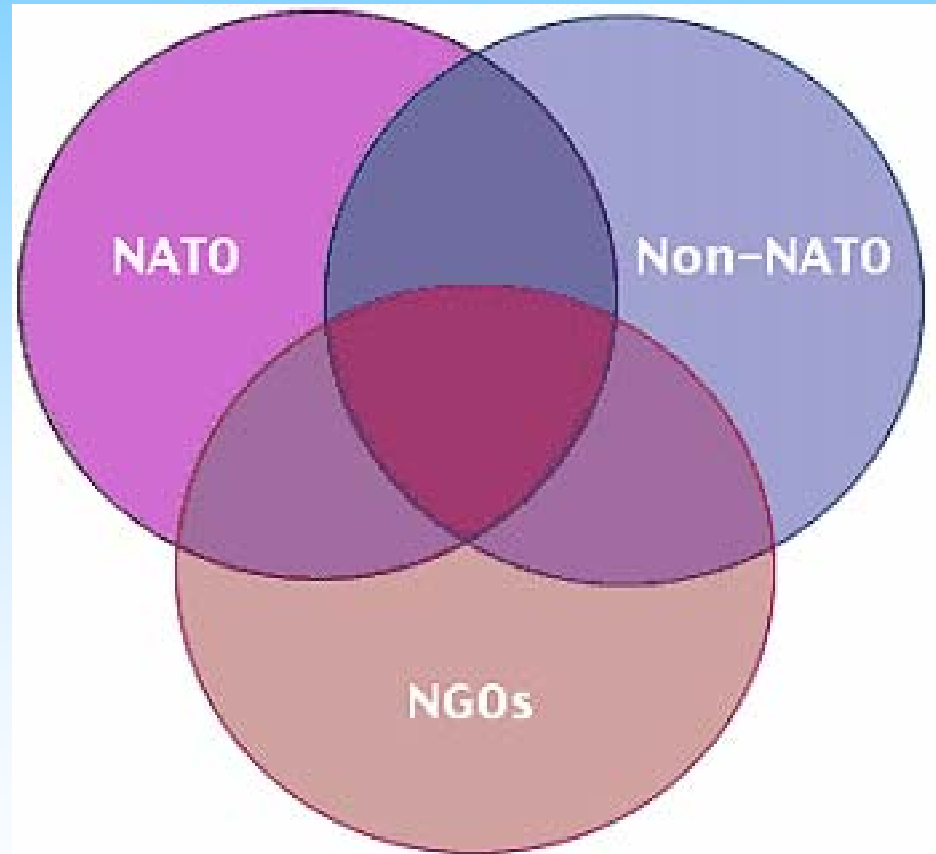
Chair, NOSWG

NC3B SC/5 WG/4

NATO Research and Technology Organisation

27 September 2004

NATO
The Hague, The Netherlands

Diverse NATO Operations

- **Most international operations in which NATO is involved with today, tend to be quite diverse in scope.**
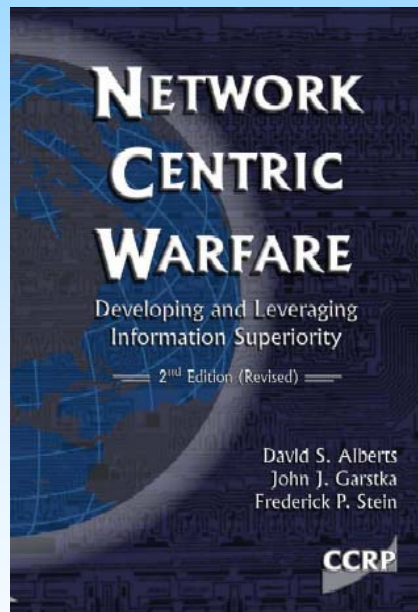
Demands on the Scale of International Operations

- **Underlying architecture(s) must be**
  - **Flexible enough to address evolving requirements;**
  - **Integrate new and emerging technologies into the current baseline.**

Prague Summit 2002

Shortly after the Prague Summit, the NC3 Board developed a strategy based on:

- **US NCW**
- **UK NEC**

. . . and Formed the NNEC Feasibility Study

NETWORK CENTRIC WARFARE

Developing and Leveraging Information Superiority

2nd Edition (Revised)

David S. Alberts
John J. Garstka
Frederick P. Stein

CCRP

Design Reference Scenarios:
#1 - 'Afghanistan-like' Operations
#2 - Urban Operations
#3- Maritime-Littoral Operation

Input: Planning situations

NRF Focused

NNEC Feasibility Study

Human

Interoperability Concepts

Information

NNEC CIS System Concepts

Technology

Input: National Plans Commercial Trends

Technology Trends

NNEC Attributes

- **Innovative Technologies**
- **Innovative capabilities**
- **Sustained information superiority**
- **. . . Global impact**

SEAMLESS NETWORK SOLUTIONS.

'

Focus on Transformation

"Transformation is more about the journey than the destination."

- **NNEC priorities and actions.**
- **Supreme Headquarters Allied Command Transformation (ACT) as a transformation proponent**
- **Transforming platform-centric to net-centric force**

Net-Centric Enablement

"Enhancing Information Sharing Activities"

Network Centric Warfare: a warfighting concept that enables a network centric force to significantly increase combat power by achieving:

Increased Awareness

Shared Awareness

Ability to Self-Synchronize

Degree of Interoperability

Operational Tempo

Survivability

Lethality

Responsiveness
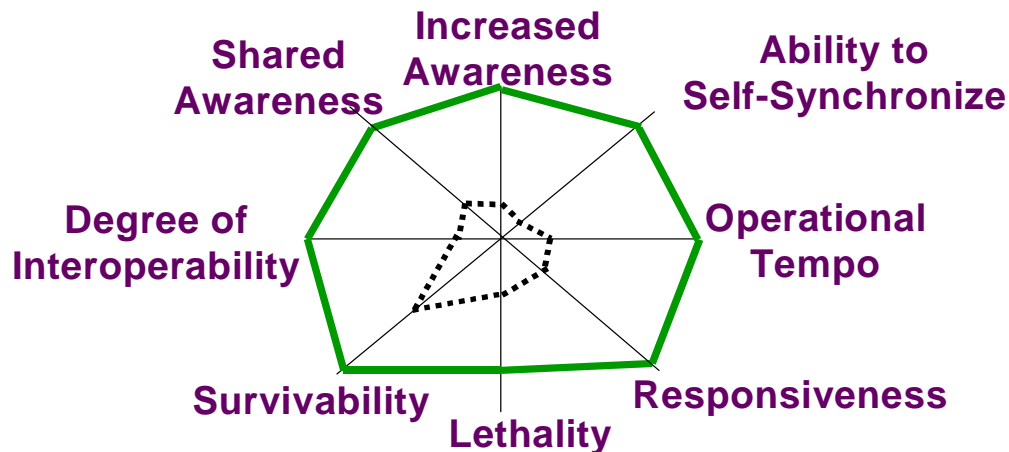
Attributes of Platform-Centric Operations

Attributes of Network-Centric Operations

NNEC Concept
"Put it to the Test!"

NATO Rapid Response Force

NNEC as a Force Multiplier
"NATO Response Force on Air, Land, or Sea."

Technology
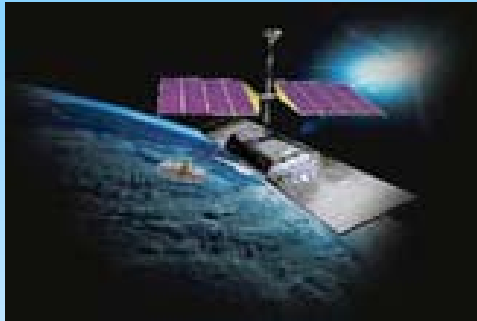
Embrace NNEC as Soon as Feasible
General Kujat: "Net-Centric NRF with capable C2ISR systems that collaborate while providing COP."
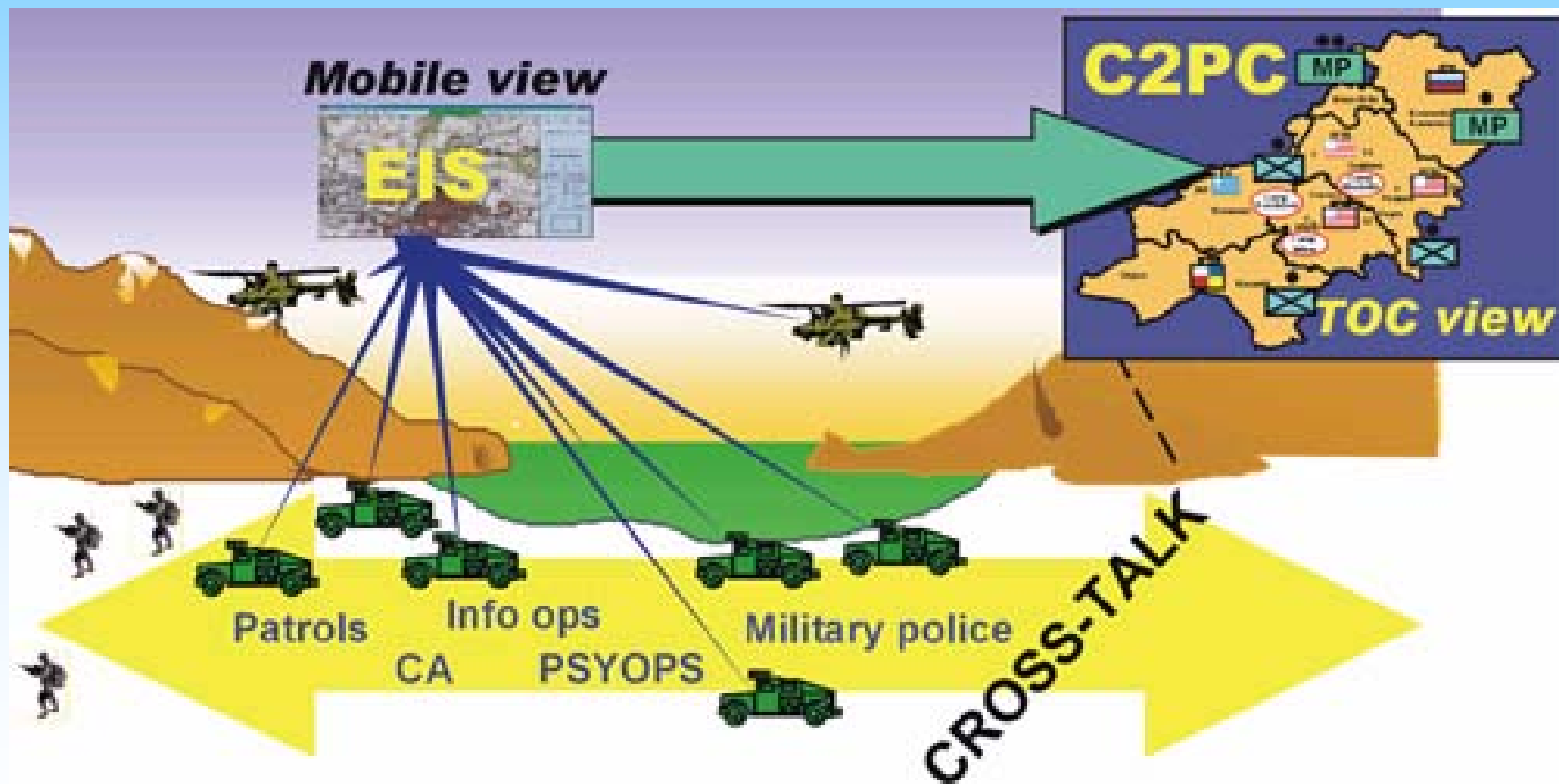
Global Reach of NNEC Operations
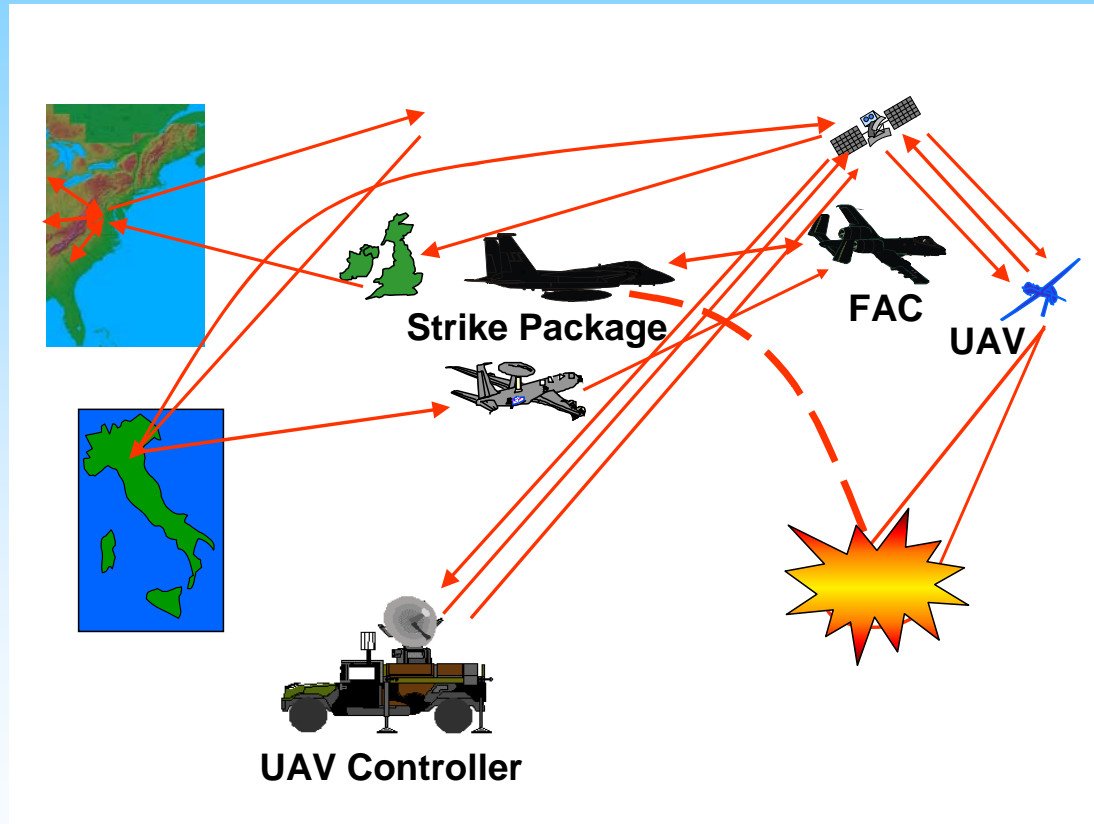
NC3TA: Solid NNEC Foundation

NRF Challenges

NC3TA Foundation

NC3TA as a NNEC Key Enabler

CD&E

MNE 3

CMX04

CMX05

R&T Input

MNE 4

E5

E6

NRF
CONCEPT

IOC

FOC

AR04   AS04   AR05   AS05

NRF
CAPABILITY

AW05

R&T Input

AA05

TRAINING

AW04

AA04
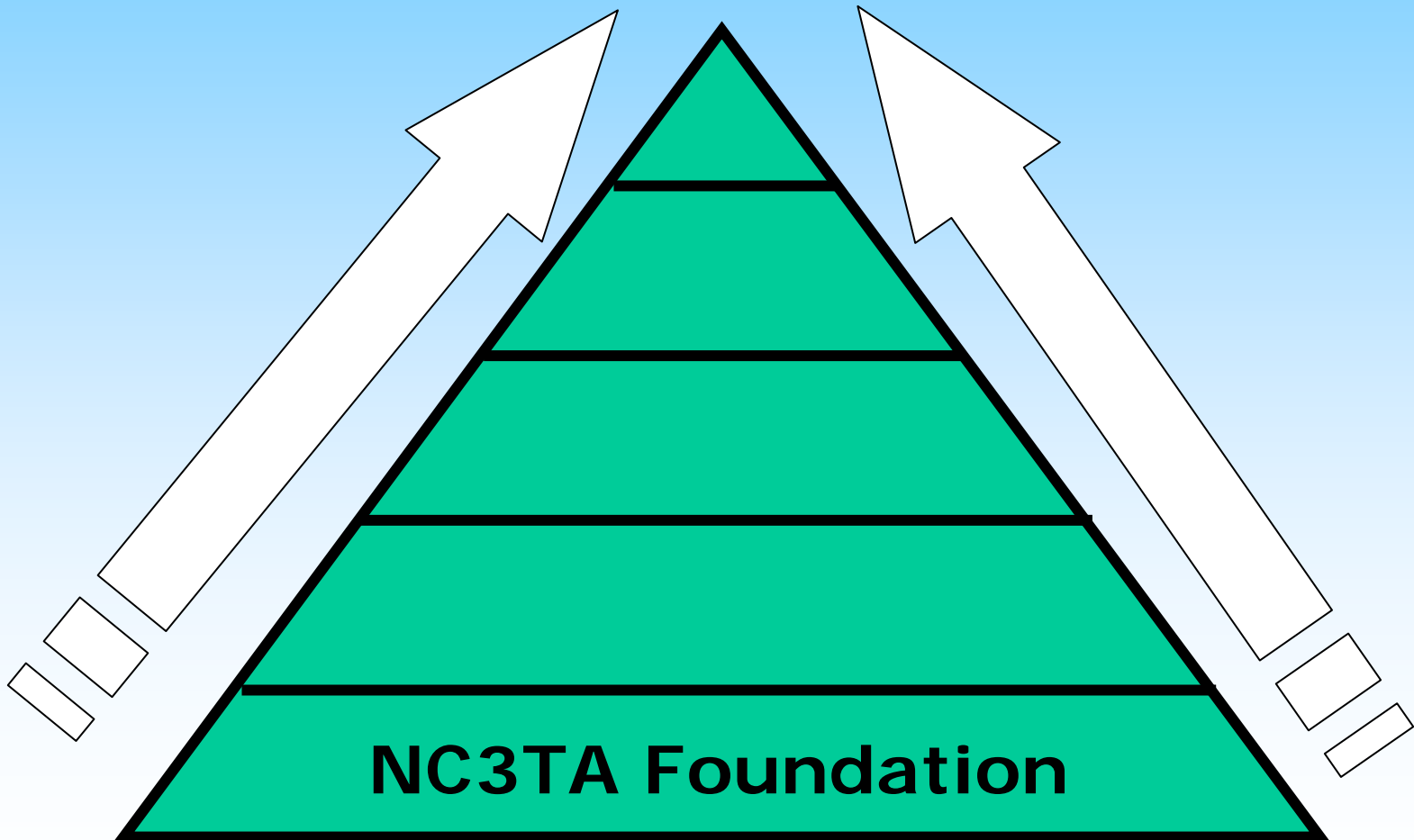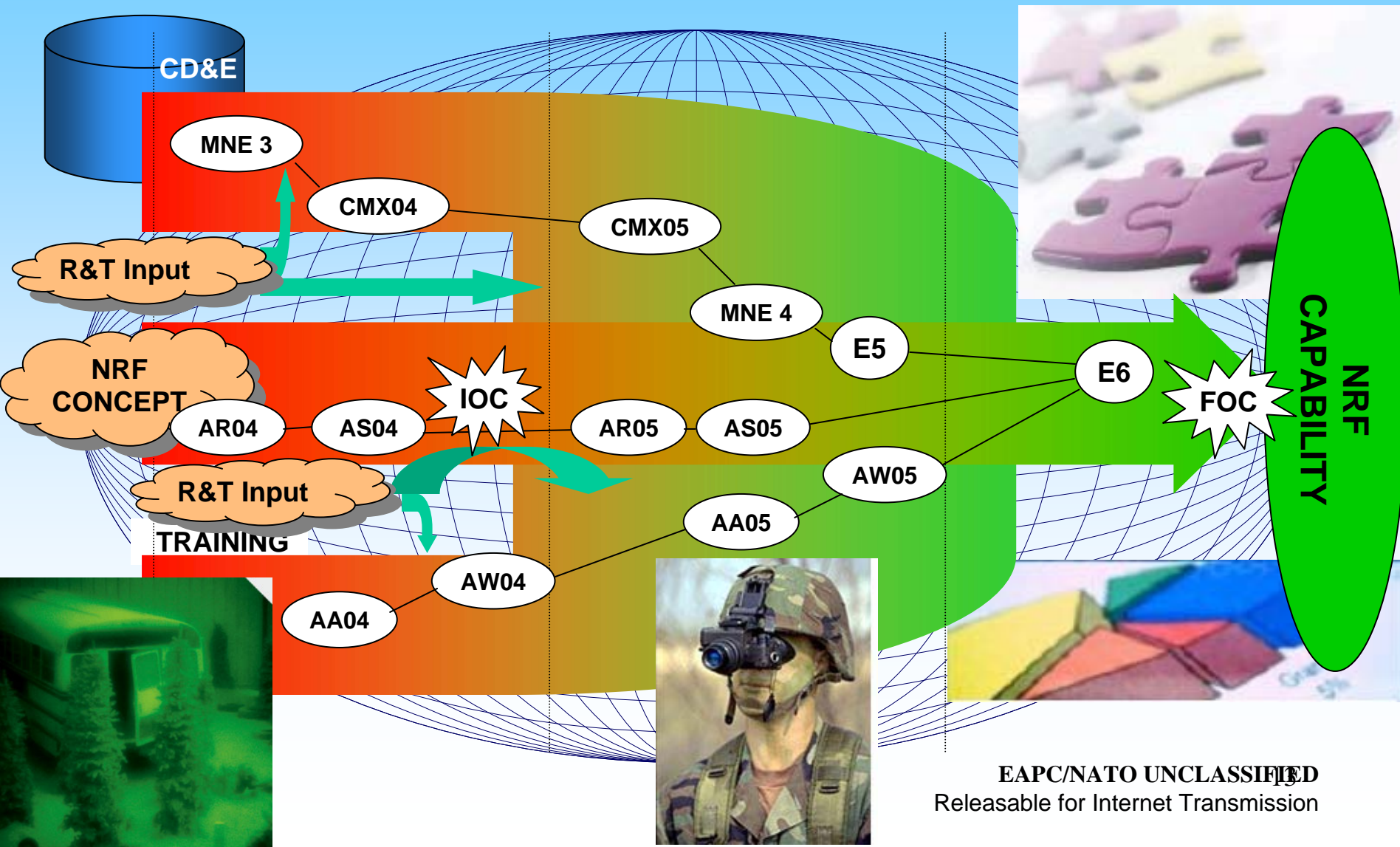
NC3TA as a NNEC Key Enabler
"Information Sharing"
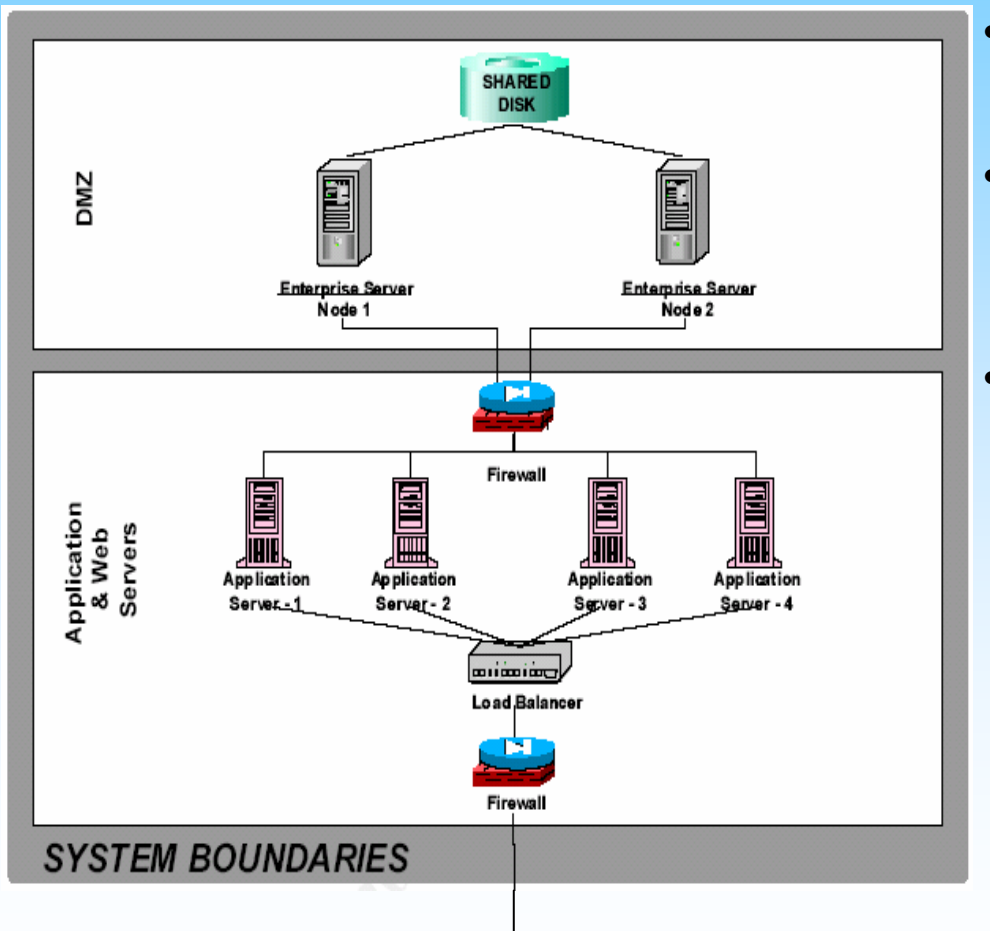
- **Support current architecture paradigms**

- **Evolve rapidly enough to keep abreast of new and emerging technologies**

- **Focus on boundaries, to achieve architectural diversity and independence.**
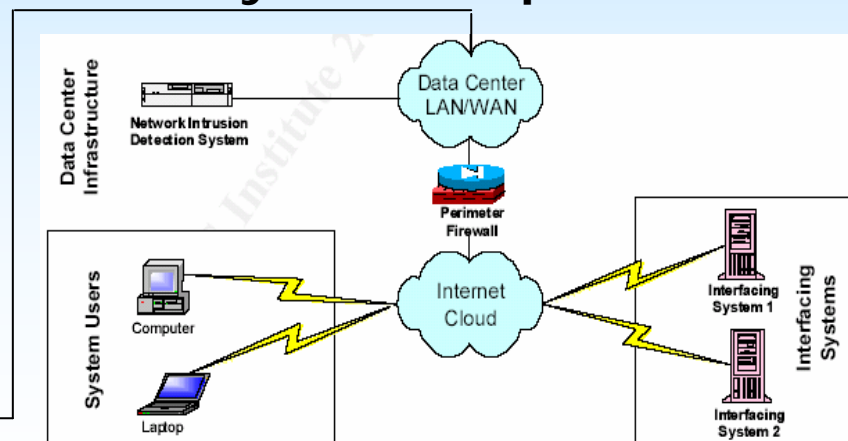
NC3TA as a NNEC Key Enabler
"Experience in Open Standards for adaptive and diverse information sharing capabilities."

Multiple Input, Multiple Output (MIMO), Adaptive Antenna Array

NC3TA as a NNEC Key Enabler
"Services-Oriented Architecture Approach"
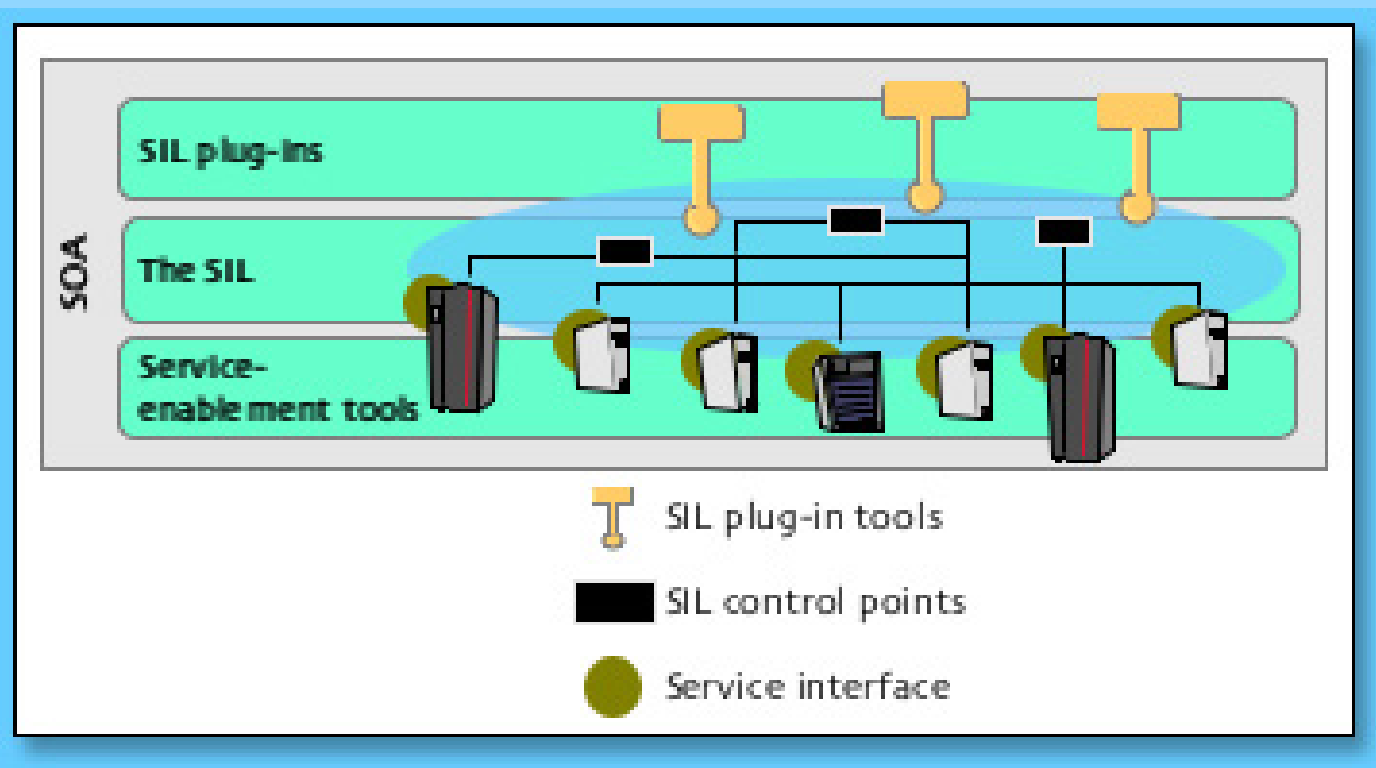
Surface Infrastructure Layer (SIL) of an SOA

NC3TA as a NNEC Key Enabler
"NOSWG Governance of NC3TA"

NOSWG Governance of NC3TA

Vol. 1	Vol. 2	Vol. 3	Vol. 4	Vol. 5
MANAGEMENT	Architectural models & Descriptions	Base standards & profiles	NCSP	NCOE

Agreed Changes

Syndicate 1, Syndicate 2, Syndicate 3, . . .

Standards for Technical Views

NATO and National:
- PMs
- Engineers
- Planners
- Budgeters
- Architects
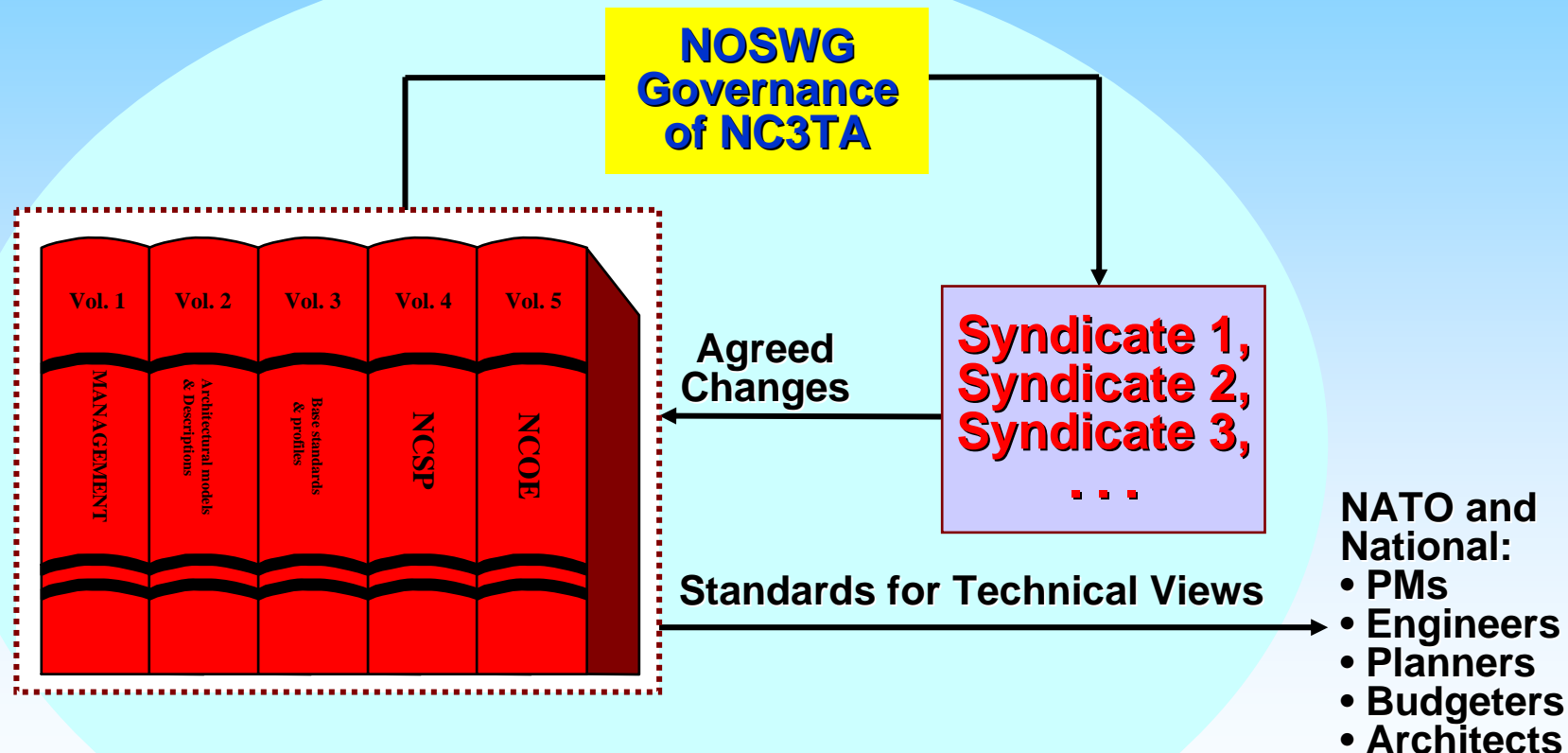
NC3TA as a NNEC Key Enabler
"Foundational Experience of NC3TA"

- **NATO is facing several challenges:**
  - **NATO Response Force (NRF)**
  - **NATO Networking Enabled Capability (NNEC) - sharing information a new way**
  - **Tracking emerging technology**
- **" . . . the NATO C3 Technical Architecture (NC3TA) is a key enabler to meet these challenges."**

Architectural Vision
"New and Developing Architectural Approaches"
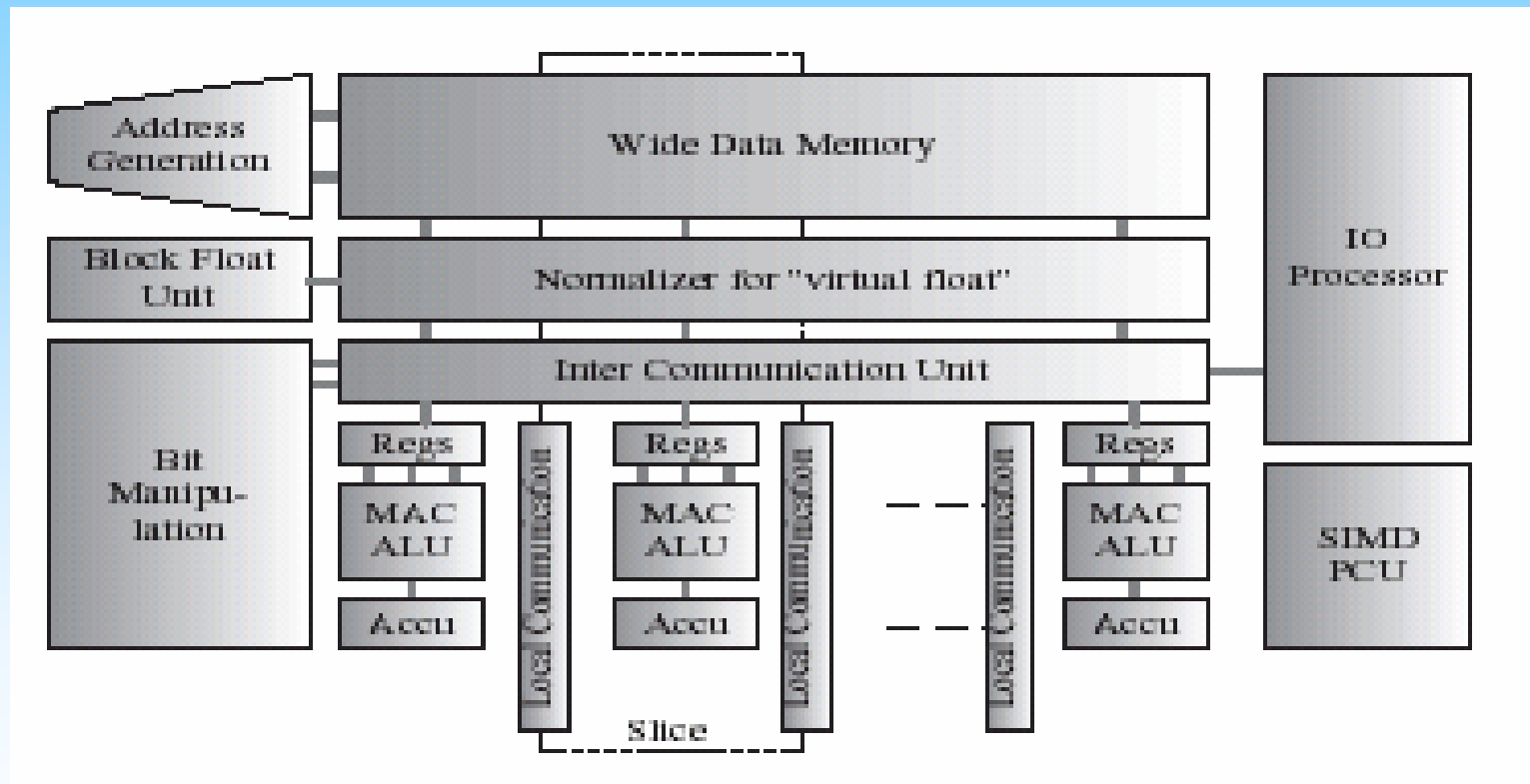
Sliced, Scalable DSP Architecture

Architectural Vision
"Evolving to Support an SOA Paradigm"
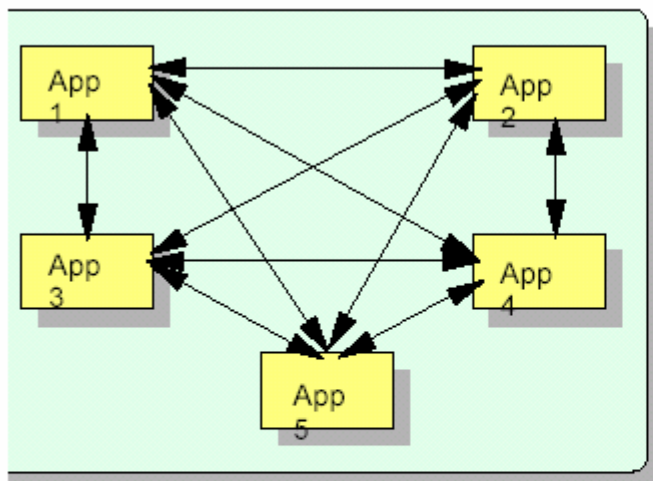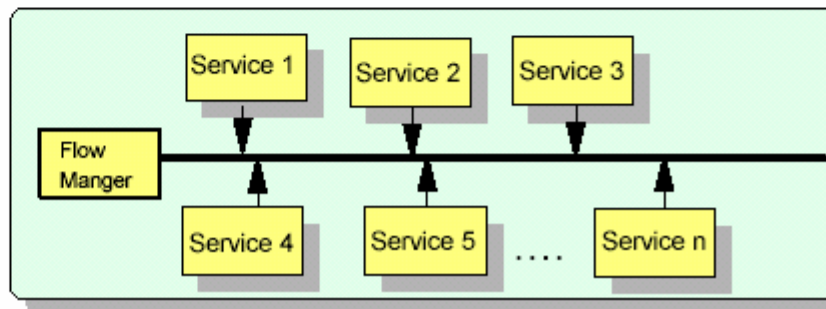
Source (IBM): http://evolve.dstc.edu.au/presentations/tut/edward_tuggle_evolve03.pdf
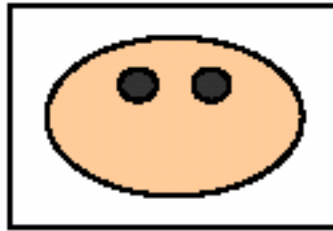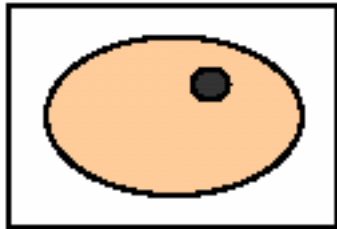
Architectural Vision
"Syntactic and semantic declarations via controlled vocabularies . . ."
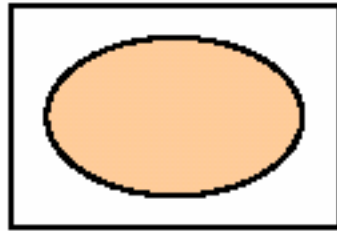
(a) Initial Drawing

(b) User A adds two black circles as eyes.

(c) User B erases a circle, and violates user A's semantic intention.

Syntactic conflict

Semantic conflict

Semantic accuracy

Data consolidation

Source: http://www.cit.gu.edu.au/~david/CSCW02CEW/submissions/Wang2.pdf

Restructuring for the Future
"NC3TA Is Currently Comprised of Five Volumes"

- **Volume 5 will need to reflect Net-Centric Enabled Services**
- **The content of other current volumes will require revisions accordingly.**

‘

Role of Research Organizations

- **The NOSWG draws upon the expertise of many individuals and organizations in compiling its vast body of corporate knowledge.**

  - This effort is only our contribution towards the overall NC3O approach to the NNEC.

  - Achieving its vision will likewise require the input of considerable intellectual horsepower from organizations such as the RTA.
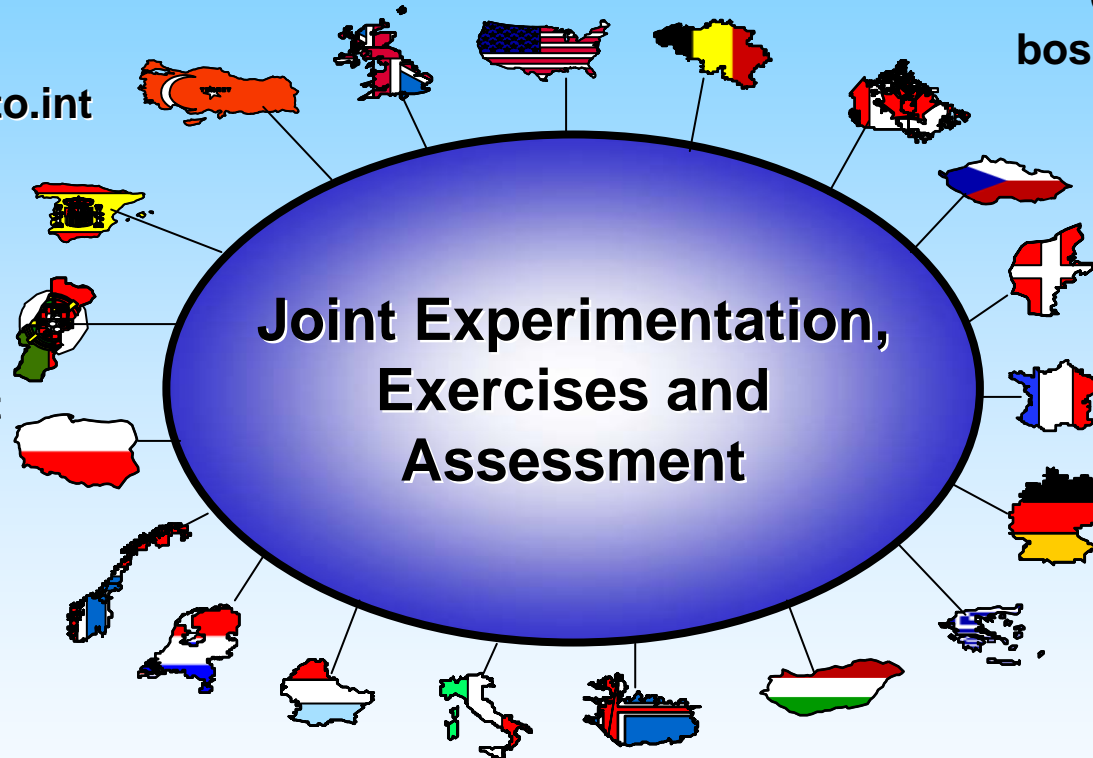
'

Conclusion

- **The NC3TA plays an important part in support of the NNEC concept, and ultimately NRF operations.**

  - **It offers broad and vital support for the design and development of systems seeking to attain information superiority.**

  - **It also has much to offer the coalition CIS (C4ISR) architectures that are the particular focus of this symposium and their information exchange capabilities.**

- **However, in order to realize its vision, the NOSWG must continually rely on vital research activities such as yours in order to shape its future direction and maintain the benefit that it delivers to the organization as a whole.**